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Comparing these two gases, it is evident that the illuminating gas used has a greater heating power than the natural gas, for in the illuminating gas there is 47.65 per cent. of hydrogen, and the heat units yielded by hydrogen are 34.462; while the chief constituent of the natural gas is marsh-gas (CH_4), which yields only 13.063 heat units, and this is practically the only heat-producing substance in the natural gas, all other gases being present in such small quantities.

In the tests upon coals, the first four were made upon Leavenworth coal, and the last two on Cañon City coal. It is evident that the process is not suited to determine the relative heating value of different samples of coal, and, indeed, that is not the intention.

If the average result obtained is taken, namely, that one ton of coal is equivalent in heating power to 21,500 cubic feet of gas, then, with Leavenworth coal at $2.50 per ton, gas would have to be sold at about twelve cents per thousand to be the equivalent in cost of the coal. Of course, as the coal increases in price, the cost of gas may also be raised proportionately. There is no doubt that the natural-gas producers in some of our districts could afford to furnish gas at this figure, but in others the price would be too low.

In the consideration of the relative heating power of the two fuels, no account is taken of the extreme convenience, wholesomeness and cleanliness of gas, nor of the fact that it can be lighted at any time when it is needed, and as soon as the work is done it can be extinguished. For convenience, then, there is nothing to equal gas; but this fuel must be sold at an extremely low price to compete economically with coal.

Lawrence, December 26, 1899.

ON THE EFFECT OF OXYGEN UPON ANIMAL LIFE.

BY J. T. WILLARD AND A. T. KINSLEY, EXPERIMENT STATION, MANHATTAN.

Read before the Academy, at Topeka, December 28, 1900.

The general view of those who think of it at all is that an atmosphere of pure oxygen would be most deleterious to animal life. That this view is not confined to the unscientific may be readily shown by reference to various authors. The following may be cited as typical:

J. F. W. Johnston, in his "Chemistry of Common Life," published in 1869, says: "Animals breathe oxygen with an increase of pleasure; but it excites them, quickens their circulation, throws them into a state of fever, and finally kills them by an excess of excitement. They live too rapidly in pure oxygen gas, and burn away in it like the fast-flaring candle. Did the atmosphere consist of oxygen only, the lives of animals would be of most brief duration."

C. W. Kimmins, in his "Chemistry of Life and Health," 1892, says: "The removal of nitrogen from the atmosphere would be as fatal as the removal of oxygen; and universal death would be accompanied by universal conflagration."

Gray says: "The Creator has adapted the atmosphere to the support of life, as anything which destroys the relation thus established renders it deleterious to the animal constitution."

Dr. B. W. Richardson seems to be one of the few who have made experiments as well as statements. He confined mice in a chamber of oxygen. In the first experiment, conducted at a temperature of fifty-five degrees F., the mouse was dead at the end of four hours. The second experiment was conducted at a temperature of seventy-five degrees F., and the mouse was taken out in deep sleep at the end of the ninth hour. In a third experiment, at sixty-five degrees F., the mouse was dead in four hours and forty-two minutes.

T. H. Dinsmore, jr., also experimented, using mice and kittens confined in large jars of oxygen. They were left in thirty to sixty minutes in general, but one kitten that was left in an hour and a half was removed in an unconscious state. This result was attributed to the accumulation of carbon dioxide. In the other cases no result was observed except an increase in the rate of respiration. After remaining in the oxygen an hour they were apparently as well as when first placed in the gas. These experiments can hardly be regarded as conclusive because of their short duration.

It should be mentioned further, before taking up a description of our own work, that one or two writers do state that animals may live in oxygen without inconvenience; but no experimental evidence is adduced on the point.

In our investigations we designed to experiment with a variety of animals, introducing them gradually into the atmosphere of oxygen, and retaining them under its influence for a somewhat prolonged period. We also deemed it wise to avoid the use of animals which, like mice, cannot endure much handling even under normal conditions. The animals were enclosed in a tight wooden box one cubic foot in capacity. It had a glass front. An opening at the top for the introduction of the animals was closed by means of a tin lid which rested in a a groove into which melted wax was poured. Openings fitted with glass tubes, which could be closed with rubber stoppers, communicated with tin dishes for food and water. Two other openings served to admit oxygen at one of the lower corners, and for its exit at the upper diagonally opposite one. The box also contained a flat tin dish, partially filled with a solution of sodium hydroxide, the dish being covered with wire screen. A layer of sawdust was placed in the bottom of the box. The oxygen used was prepared from a mixture of potassium chlorate and manganese dioxide, and was stored for at least a week before use in cylinders. The oxygen was delivered from the cylinders, passing through a wash-bottle containing water, which served as an index to the rate of supply, and thence into the respiration chamber.

The storage of the gas was for the purpose of affording ample time for the absorption of all solids projected over in its preparation, and the gas as delivered was perfectly clear, though doubtless not chemically pure. A steady, though not very rapid, current of the gas was maintained throughout the continuance of each experiment. Sometimes, if the animal seemed oppressed, the current of gas was quickened for a time. It was thought that the rate of transmission, with the assistance of the sodium hydroxide solution, was sufficient to keep the excretory gases removed.

Five experiments were made, and in all but the second the animals were watched practically continuously. In the second the watching was continued for the first nineteen hours, and after that the time between observations was never longer than four hours.

First Experiment.—In this experiment a grown male cat was confined in the respiration chamber at five P. M., April 15, 1899. From the nature of the arrangements, observations could be made upon the respiration and general behavior only. In this, as in all of the experiments, the animal was put into the chamber while it was filled with air, and this was gradually displaced by the oxygen. The cat remained in the apparatus until 10:45 o'clock A. M. the next day, or nearly thirty hours. The table below is a record of the observations made:

Time. P. M.	Respiration. Rate per min.	Remarks.
5:00	24	Just before putting into the apparatus.
5:30	24	Asleep.
6:00	29–30	Awake; lying still.
6:30	32	Asleep.
7:30	30–32	Awake; lying still.
8:00	31–32	Asleep.
10:00	32–33	Asleep.
12:00	32–33	Up; looking around.
A. M.		
3:30	34–35	Asleep.
4:30	——	Moving around; breathing a little short.
5:00	34	Sitting up.
6:00	41–42	Breathing short and jerky.
7:30	38	Sat on haunches and ate some.
8:30	35	Asleep.
10:00	27	Looking around.
10:45	——	Termination of experiment.

The only time that the animal gave any signs of distress was when his respiration was short and jerky, but these symptoms did not last long. During the progress of the experiment we had from time to time tested the outgoing gas by means of a splinter with a spark at the tip. On plunging this into the exit tube the spark would burst into a blaze. At 10:45, on performing this experiment, an explosion took place which blew off the lid, and broke the glass front out of the apparatus, thus bringing the experiment to an untimely end. The cat was singed somewhat by the explosion, and was a little stiff from his confinement, but otherwise seemed to be unaffected. His respiration had become about normal, and we have no reason to doubt that he might have lived there indefinitely had oxygen been supplied and no accident supervened.

In respect to the cause of the explosion, which must have been due to the production of some combustible gas, the only explanation that we can suggest is, that the gas may have been of intestinal origin. It is very surprising to us that the quantity could be sufficient to produce the result observed. The oxygen itself was tested and found to be non-explosive, and, in fact, the cylinders had never been used for holding hydrogen or other combustible gases. Had time permitted, we would have been glad to pursue this phase of the subject further, but were unable to at the time.

Second Experiment.—A white rabbit was placed under the same conditions as the cat, and similar observations made. The notes are omitted, as no noticeable change took place. Aftcr fifty-three hours the rabbit was removed, apparently in as good condition as when he went in. Grass and clover were eaten heartily during the experiment.

Third Experiment.—In this case a bantam hen and an ordinary chicken about four weeks old were put into the respiration chamber together. They were provided with perches. The little chicken had a hard time of it, as the old hen fought it almost constantly while awake. They remained in the oxygen forty-four hours and seemed to be in perfect condition at the conclusion of the experiment. At one time, when the current of oxygen was somewhat slow, they showed some gasping and were depressed in spirits. This was about three hours before the conclusion of the experiment, and on turning on a more rapid current of the oxygen, the symptoms entirely disappeared, the old hen became quite lively, and began to chase the little chicken again, and abused it severely until the close of the experiment.

Fourth Experiment.—The rabbit used in the second experiment was again confined in the apparatus for twenty hours, then immediately killed and dissected. No change could be detected in the organs. The blood seemed to clot more rapidly than normally, and the arterial blood was of a brighter hue. The venous blood was also probably a very little changed in color.

Fifth Experiment.—Two bantam hens were placed in the apparatus under the same conditions as in the third experiment. They were kept there for six days and twenty-one hours. We had planned to continue the experiment a full week, but the oxygen supply became exhausted. We could not see that they were affected in the least at any time.

From these experiments, we feel justified in concluding that an atmosphere of oxygen produces no permanent excitation, and no unnatural sleep or unconsciousness, and is not destructive to animal life.

EFFECT UPON THE COMPOSITION OF THE SOIL OF CONTINUOUS CROPPING BY WHEAT.

BY J. T. WILLARD, EXPERIMENT STATION, MANHATTAN.

Read before the Academy December 28, 1900.

In the fall of 1880, Prof. E. M. Shelton, of the Kansas State Agricultural College, laid out an acre of land to be devoted to the continuous production of winter wheat, without fertilization or renovating treatment of any kind. This experiment was doubtless suggested by the famous plat at Rothamsted, England, which Lawes and Gilbert have kept under such conditions since 1844. Unfortunately the plat selected by Professor Shelton was situated so that the growth of the institution has seemed to compel the abandonment of the experiment. The plat also, having a rather pronounced slope, was not as well adapted to the purpose of the experiment as would be desirable.

The abandonment of the experiment having been determined upon, it seemed of interest to make analyses of the soil of the plat, and, for comparison, of that of the adjoining field, which has borne a variety of crops, though not in any regular rotation. For sampling these fields four spots were selected in each, and pits sunk to the depth of the proposed sampling. A prism of soil six inches square was then cut from the side of each and divided into four parts, representing, respectively, the first nine inches from the top, and three intervals below this of twelve inches each. Four samples were thus obtained from each field for each depth. These four samples were then intimately mixed to form a composite sample, which was carefully air-dried and subsampled for analysis.

The analyses were limited to determinations of the moisture, insoluble residue, potash, lime, nitrogen, and phosphoric acid. The accompanying table exhibits the results as calculated to a water-free basis:

TABLE showing (I) composition of soil at several depths, from field cropped in wheat continuously for eighteen years; and (II) that from an adjacent field that had borne a variety of crops during the same period. Results calculated to a water-free basis, and in percentages.

	0 to 9 ins.		9 to 21 ins.		21 to 33 ins.		33 to 45 ins.	
	I.	II.	I.	II.	I.	II.	I.	II.
Potash	0.720	0.656	0.584	0.716	0.653	0.631	0.615	0.694
Lime	0.750	0.686	0.740	0.722	0.733	0.611	0.811	0.826
Nitrogen	0.216	0.245	0.169	0.152	0.104	0.117	0.087	0.081
Phosphoric acid	0.107	0.140	0.044	0.092	0.017	0.053	0.028	0.061
Insoluble residue	83.948	83.107	81.524	80.723	84.335	83.004	85.281	84.216